

E 1.28: SOLAR / 2015-79/04

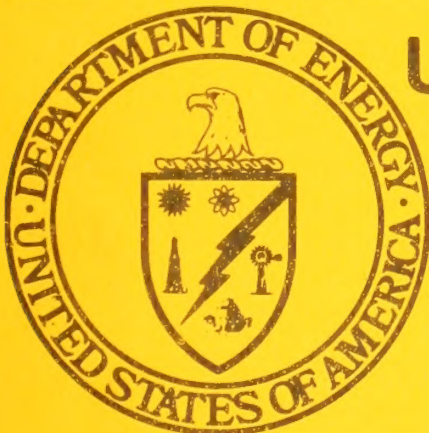
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SOLAR/2015-79/04

# Monthly Performance Report

KALWALL CORPORATION

APRIL 1979



## U.S. Department of Energy

National Solar Heating and  
Cooling Demonstration Program

National Solar Data Program

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MONTHLY PERFORMANCE REPORT  
KALWALL CORPORATION  
APRIL 1979

## I. SYSTEM DESCRIPTION

The Kalwall Corporation solar-energy system is a passive space-heating system of the direct gain type (Figure 1). The heated space (approximately 10,000 square feet) is a portion of a commercial warehouse in Manchester, New Hampshire. Solar energy is admitted through vertical double-glazed Kalwall panels covering the entire south and east walls. Storage is provided by the dark colored six-inch thick concrete floor of the building and the contents of the warehouse. Summer overheat protection is provided by both an overhang on the south roof edge and by natural ventilation. Auxiliary energy is provided by two liquid-to-air heat exchangers supplied by the building boiler. Control thermostats for the auxiliary system are set at approximately 60°F. Five thermostatically controlled circulating fans located along the south wall assist in distribution of the collected solar energy by operating when the temperature near the fan falls below 60°F or rises above approximately 90°F.

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The system was designed to satisfy approximately 50 percent of the annual space heating demand. However, the design performance projections were made before additional insulation was added to the building roof. Consequently, revised design performance projections would be expected to predict a solar contribution of greater than 50 percent. Results of previous performance analysis for the near-average winter of 1977-1978 have shown that the system does perform above these design projections.

## II. PERFORMANCE EVALUATION

### A. Introduction

The Kalwall Corporation passive solar energy system provided 81 percent of the space heating energy requirements of the warehouse, resulting in the savings of an estimated 175 gallons of fuel oil for the month.

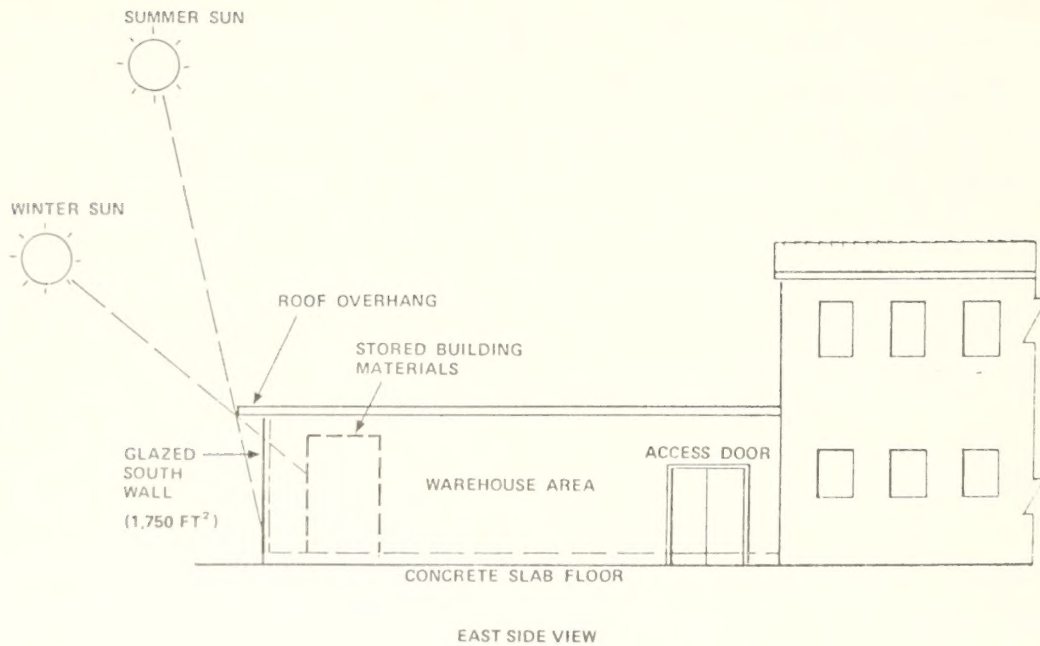
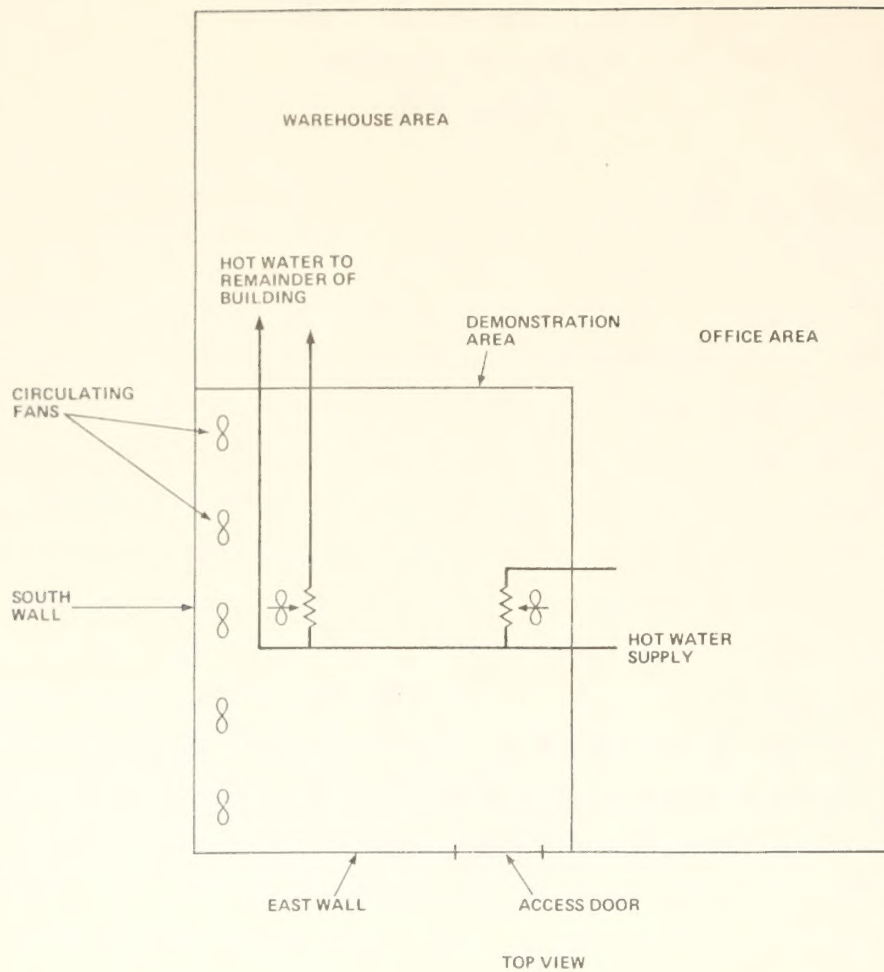


Figure 1. KALWALL CORPORATION PASSIVE SOLAR SPACE HEATING SYSTEM

The solar energy thermal storage provided several days of thermal reserve for heating. Accuracy of the performance analysis results has been degraded due to the lack of proper instrumentation, since required instrumentation in the auxiliary hot water supply line has not been installed.

#### B. Weather

During April, the daily average incident solar energy was  $690 \text{ Btu/ft}^2\text{-day}$ , which was less than the long-term average of  $829 \text{ Btu/ft}^2\text{-day}$  derived from measurements at the nearby Boston, Massachusetts weather station. The average outside ambient temperature of  $47^\circ\text{F}$  was 1 degree less than the long-term average reported for Boston.

#### C. System Thermal Performance

Of the estimated 53.5 million Btu of solar energy that was incident normal to the south and east walls of the building, approximately 16.0 million Btu were collected, resulting in a collection efficiency of 30 percent. It should be noted that this collection efficiency does not include losses through the glazing. These losses are accounted for as a part of the building load. The space heating thermal demand for April was 18.17 million Btu. The demand was reduced from the building heating load of 18.66 million Btu by thermal energy from the fan operation (0.49 million Btu). Solar energy satisfied 81 percent of this demand. An estimated 3.43 million Btu of auxiliary thermal energy was consumed during April.

System thermal storage provided both adequate thermal reserves and adequate damping of variations in daily building temperature during April. During a period of low incident energy (April 29), energy released from storage provided a significant amount of the solar energy used by the building. The thermal storage mass also helped to reduce daily variations in building temperature by absorbing energy during the day and releasing the energy back to the building at night. This is illustrated by the relatively small average daily variation in building temperature ( $7^\circ\text{F}$  for the month) and by the  $0.2^\circ\text{F}$  difference in average building and storage temperatures.



#### D. Observations

The solar energy used is computed as the difference between the space heating demand and the auxiliary thermal energy used. Since a significant amount of the auxiliary energy used was due to uncontrolled transfer from the hot water supply line, the accuracy of the analysis is degraded if the hot water supply line is not adequately instrumented. One flow measurement and two temperature measurements (inlet and outlet) are required for determination of the heat loss from the pipe. However, during April the flow measurement and one of the temperature measurements were not yet installed. Estimates of these measurements were made using other measurement data which resulted in reasonable calculated performance. However, errors were introduced which cannot be quantified.

As of the first of March and continuing through April, the use of the building changed. Building materials were no longer stored in the warehouse. Consequently, the amount of solar energy storage capacity was reduced. Also, the auxiliary system heat exchanger fans were turned off for the entire month of April. Therefore, all auxiliary energy used was derived from uncontrolled heat exchanges from the main hot water supply line to the air in the building. This uncontrolled energy transfer was approximately 20,000 Btu per hour when the building boiler was on.

An effect of turning off the heat exchanger fans was to increase the amount of energy transferred to and from the remainder of the building through the common concrete slab floor. Instrumentation is insufficient to accurately determine the amount of energy transferred, but the effect is apparent on days when the floor temperatures reach local maximums or minimums. Since energy flow through the slab is both into and out of the demonstration area, the long-term effect over the month should be small.

Since a pyronometer was added to the instrumentation to measure energy incident on the glazed east wall, several report parameters have been changed. The total incident solar energy is the sum of the energy incident on both

the south and east walls, while the incident solar energy per square foot represents the energy available for the south wall only. The 30 percent collection efficiency is normalized to the energy available on both walls.

#### E. Energy Savings

Fossil energy savings for the building in April were 175 gallons of fuel oil. For comparison to a more conventional style of building construction, fossil energy savings were estimated against a similar building with conventional wall construction on the south and east (i.e., R-5 walls) and found to be 128 gallons of oil for the same measured environmental conditions. Energy savings compared to a building where the temperature is controlled to a set point are not presented for this application. The south wall circulating fans consumed 131 kwh of electric energy. This operating energy is applied as a penalty to electric energy savings.

### III. ACTION STATUS

Two sensors (a flow measurement and a temperature measurement) have not been installed.



# SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

## MONTHLY REPORT SITE SUMMARY

SITE: KALWALL CORPORATION  
REPORT PERIOD: APRIL, 1979

SOLAR/2015-79/04

SITE/SYSTEM DESCRIPTION: THE KALWALL SOLAR SYSTEM IS A PASSIVE SPACE HEATING SYSTEM FOR A COMMERCIAL WAREHOUSE. THE SOUTH WALL OF THE BUILDING IS CONSTRUCTED OF TRANSPARENT SYNTHETIC PANELS WHICH ADMIT SOLAR ENERGY INTO THE BUILDING. THE CONCRETE FLOOR SERVES AS AN ABSORBER AND STORAGE MEDIUM. CIRCULATING FANS ALONG THE SOUTH WALL ARE USED FOR ENERGY DISTRIBUTION.

### GENERAL SITE DATA:

INCIDENT SOLAR ENERGY 53.500 MILLION BTU  
20714 BTU/SQ.FT.  
15.990 MILLION BTU  
9137 BTU/SQ.FT.  
47 DEGREES F  
63 DEGREES F  
0.28  
0.448 MILLION BTU  
0.448 MILLION BTU  
18.620 MILLION BTU

### COLLECTED SOLAR ENERGY

AVERAGE AMBIENT TEMPERATURE  
AVERAGE BUILDING TEMPERATURE  
ECSS SOLAR CONVERSION EFFICIENCY  
ECSS OPERATING ENERGY  
TOTAL SYSTEM OPERATING ENERGY  
TOTAL ENERGY CONSUMED

### SUBSYSTEM SUMMARY:

	HOT WATER	HEATING	COOLING	SYSTEM TOTAL
LOAD	N.A.	18.171	N.A.	18.171 MILLION BTU
SOLAR FRACTION	N.A.	81	N.A.	81 PERCENT
SOLAR ENERGY USED	N.A.	14.744	N.A.	14.744 MILLION BTU
OPERATING ENERGY	N.A.	0.448	N.A.	0.448 MILLION BTU
AUX. THERMAL ENERGY	N.A.	3.428	N.A.	3.428 MILLION BTU
AUX. ELECTRIC FUEL	N.A.	N.A.	N.A.	N.A. MILLION BTU
AUX. FOSSIL FUEL	N.A.	N.A.	N.A.	N.A. MILLION BTU
ELECTRICAL SAVINGS	N.A.	-0.448	N.A.	-0.448 MILLION BTU
FOSSIL SAVINGS	N.A.	24.573	N.A.	24.573 MILLION BTU
SYSTEM PERFORMANCE FACTOR:		12.177		

\* DENOTES UNAVAILABLE DATA

@ DENOTES NULL DATA

N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT  
OF THE NATIONAL SOLAR DATA PROGRAM, FEBRUARY 28, 1978.  
SOLAR/0004-78/18



# SOLAR HEATING AND COCLING DEMONSTRATION PROGRAM

## MONTHLY REPORT SITE SUMMARY

SITE: KALWALL CORPORATION  
REPORT PERIOD: APRIL, 1979

SOLAR/2015-79/04

SITE/SYSTEM DESCRIPTION: THE KALWALL SOLAR SYSTEM IS A PASSIVE SPACE HEATING SYSTEM FOR A COMMERCIAL WAREHOUSE. THE SOUTH WALL OF THE BUILDING IS CONSTRUCTED OF TRANSPARENT SYNTHETIC PANELS WHICH ADMIT SOLAR ENERGY INTO THE BUILDING. THE CONCRETE FLOOR SERVES AS AN ABSORBER AND STORAGE MEDIUM. CIRCULATING FANS ALONG THE SOUTH WALL ARE USED FOR ENERGY DISTRIBUTION.

### GENERAL SITE DATA:

INCIDENT SOLAR ENERGY

COLLECTED SOLAR ENERGY

AVERAGE AMBIENT TEMPERATURE

AVERAGE BUILDING TEMPERATURE

ECSS SOLAR CONVERSION EFFICIENCY

ECSS OPERATING ENERGY

TOTAL SYSTEM OPERATING ENERGY

TOTAL ENERGY CONSUMED

56.443 GIGA JOULES  
235230 KJ/SQ.M.  
16.870 GIGA JOULES  
103764 KJ/SQ.M.

8 DEGREES C  
17 DEGREES C

0.28 GIGA JOULES  
0.473 GIGA JOULES  
0.473 GIGA JOULES  
19.644 GIGA JOULES

### SUBSYSTEM SUMMARY:

LOAD  
SOLAR FRACTION  
SOLAR ENERGY USED  
OPERATING ENERGY  
AUX. THERMAL ENG  
AUX. ELECTRIC FUEL  
AUX. FOSSIL FUEL  
ELECTRICAL SAVINGS  
FOSSIL SAVINGS

HEATING

COOLING

SYSTEM TOTAL

19.171 GIGA JOULES  
81 PERCENT  
15.555 GIGA JOULES  
0.473 GIGA JOULES  
3.616 GIGA JOULES  
N.A. GIGA JOULES  
N.A. GIGA JOULES  
-0.473 GIGA JOULES  
25.924 GIGA JOULES

### SYSTEM PERFORMANCE FACTOR:

\* DENOTES UNAVAILABLE DATA  
@ DENOTES NULL DATA  
N.A. DENOTES NOT APPLICABLE DATA

REFERENCE: USER'S GUIDE TO THE MONTHLY PERFORMANCE REPORT  
OF THE NATIONAL SOLAR DATA PROGRAM, FEBRUARY 28, 1978,  
SOLAR/0004-78/18

# SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

## MONTHLY REPORT SPACE HEATING SUBSYSTEM

SITE: KALWALL CORPORATION  
REPORT PERIOD: APRIL, 1979

SOLAR/2015-79/04

DAY OF MON.	SPACE HEATING LOAD MILLION BTU	SOLAR FR. OF LOAD PCT	SOLAR ENERGY USED MILLION BTU	OPER ENERGY MILLION BTU	AUX THERMAL USED MILLION BTU	AUX ELECT FUEL MILLION BTU	AUX FOSSIL FUEL MILLION BTU	ELECT ENERGY SAVINGS MILLION BTU	FOSSIL ENERGY SAVINGS MILLION BTU	BLDG TEMP DEG. F	AMB TEMP DEG. F
1	0.514	100	0.514	0.038	0.000	NOT	NOT	-0.038	0.857	58	43
2	0.683	50	0.339	0.045	0.344			-0.045	0.565	57	37
3	0.603	63	0.380	0.037	0.224			-0.037	0.633	58	41
4	0.758	64	0.486	0.017	0.273			-0.017	0.809	61	41
5	0.784	49	0.383	0.032	0.401			-0.032	0.638	59	38
6	1.033	58	0.601	0.021	0.431			-0.021	1.002	60	36
7	0.984	87	0.853	0.019	0.131			-0.019	1.421	61	37
8	0.991	95	0.944	0.014	0.047			-0.014	1.574	62	39
9	0.820	72	0.588	0.041	0.233			-0.041	0.979	58	33
10	0.935	75	0.698	0.024	0.237			-0.024	1.163	59	33
11	0.834	89	0.744	0.014	0.090			-0.014	1.240	63	45
12	0.647	84	0.542	0.008	0.105			-0.008	0.904	65	50
13	0.790	71	0.559	0.004	0.231			-0.004	0.932	64	43
14	0.675	100	0.675	0.024	0.000			-0.024	1.125	59	38
15	0.602	100	0.602	0.026	0.000			-0.026	1.003	58	40
16	0.624	63	0.355	0.031	0.229			-0.031	0.658	58	39
17	0.692	91	0.628	0.018	0.064			-0.018	1.047	60	44
18	0.697	85	0.595	0.014	0.102			-0.014	0.991	62	46
19	0.701	91	0.638	0.008	0.063			-0.008	1.063	64	46
20	0.619	95	0.586	0.010	0.034			-0.010	0.976	65	50
21	0.568	94	0.533	0.004	0.036			-0.004	0.888	67	51
22	0.364	100	0.364	0.000	0.000			0.000	0.607	65	54
23	0.317	100	0.317	0.000	0.000			0.000	0.529	68	61
24	0.373	100	0.373	0.000	0.000			0.000	0.622	70	61
25	0.489	69	0.336	0.000	0.153			-0.000	0.559	70	57
26	0.204	100	0.204	0.000	0.000			0.000	0.340	70	63
27	0.162	100	0.162	0.000	0.000			0.000	0.270	66	60
28	0.176	100	0.176	0.000	0.000			0.000	0.294	69	63
29	0.256	100	0.256	0.000	0.000			0.000	0.426	67	59
30	0.275	100	0.275	0.000	0.000			0.000	0.459	71	64
SUM	18.171	-	14.744	0.448	3.428	N.A.	N.A.	-0.448	24.573	-	-
AVG	0.606	81	0.491	0.015	0.114	N.A.	N.A.	-0.015	0.819	63	47
NBS	Q402	N400	Q400	Q403	Q401		Q410	Q415	Q417	N406	N113

\* DENOTES UNAVAILABLE DATA.  
 @ DENOTES NULL DATA.  
 N.A. DENOTES NOT APPLICABLE DATA.



# SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

## MONTHLY REPORT ENVIRONMENTAL SUMMARY

SITE: KALWALL CORPORATION  
REPORT PERIOD: APRIL, 1979

SOLAR/2015-79/04

DAY OF MONTH	TOTAL INSOLATION BTU/SQ.FT	DIFFUSE INSOLATION BTU/SQ.FT	AMBIENT TEMPERATURE DEG F	DAYTIME AMBIENT TEMP DEG F	RELATIVE HUMIDITY PERCENT	WIND DIRECTION DEGREES	WIND SPEED M.P.H.
1	22	NOT	43	44	NOT	0	1
2	4		37	37		0	2
3	122	APPLICABLE	41	44	APPLICABLE	0	1
4	674		41	52		0	2
5	94		38	39		319	2
6	787		36	39		270	8
7	1023		37	42		301	12
8	1483		39	47		297	6
9	86		33	33		24	3
10	488		38	41		316	6
11	1422		45	54		308	7
12	1237		50	60		317	5
13	1018		43	54		71	3
14	1119		38	38		0	1
15	366		40	47		0	1
16	120		39	41		0	0
17	582		44	53		0	3
18	1033		46	57		312	3
19	949		46	59		336	3
20	1187		50	65		348	2
21	1224		51	65		345	1
22	495		54	65		0	1
23	1031		61	74		309	2
24	1129		61	77		312	2
25	948		57	70		0	2
26	611		62	72		151	3
27	104		60	73		102	3
28	941		63	73		0	2
29	304		59	63		0	1
30	1111		64	76		0	2
SUM	20714	N.A.	-	-	-	-	-
AVG	690	N.A.	47	55	N.A.	325	3
NBS ID	Q001		N113			N115	N114

\* DENOTES UNAVAILABLE DATA.

@ DENOTES NULL DATA.

N.A. DENOTES NOT APPLICABLE DATA.

# SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

## MONTHLY REPORT PASSIVE SPACE HEATING

SOLAR/2015-79/04

SITE: KALWALL CORPORATION  
REPORT PERIOD: APRIL, 1979

DAY OF MON	SPACE HEATING LOAD MILLION BTU	SOLAR ENERGY USED MILLION BTU	CHANGE IN STORE ENERGY MILLION BTU	AVERAGE STORAGE TEMP DEG F	DIRECT SOLAR UTIL EFFIC	AUX THERMAL USED MILLION BTU	BLOG TEMP DEG F	AMB TEMP DEG F	#WIND AVG SPEED MPH	WIND AVG DIR DEG	SOLA FR LOAD REP CENT
1	0.513	0.513	-0.119	58.6	8.409	0.000	58	43	1.3	0	100
2	0.682	0.339	-0.137	57.3	29.069	0.343	57	37	1.8	0	50
3	0.603	0.379	0.070	57.2	1.135	0.223	58	41	1.5	0	63
4	0.768	0.485	0.212	59.6	0.250	0.272	61	41	1.6	0	64
5	0.784	0.383	-0.100	58.5	1.790	0.400	59	38	2.4	0	49
6	1.032	0.601	0.082	60.2	0.358	0.431	60	36	7.8	319	58
7	0.983	0.852	0.045	60.7	0.358	0.131	61	37	11.6	301	87
8	0.991	0.944	0.254	62.8	0.267	0.047	62	39	6.1	297	93
9	0.920	0.587	-0.474	59.4	2.542	0.232	58	33	3.1	24	72
10	0.934	0.697	0.046	58.7	0.571	0.236	59	38	6.2	316	75
11	0.834	0.743	0.426	62.2	0.214	0.090	63	45	6.9	308	89
12	0.646	0.542	0.165	64.5	0.172	0.104	65	50	4.9	317	84
13	0.789	0.558	-0.034	64.9	0.211	0.231	64	43	2.7	71	71
14	0.675	0.675	-0.083	60.7	1.845	0.000	59	38	1.2	0	100
15	0.601	0.601	-0.034	59.3	0.601	0.000	58	40	1.4	0	100
16	0.623	0.394	-0.031	58.4	1.271	0.229	58	39	0.3	0	63
17	0.692	0.628	0.128	59.9	0.358	0.064	60	44	3.1	312	91
18	0.697	0.594	0.248	61.8	0.214	0.102	62	46	2.8	336	85
19	0.700	0.637	0.067	63.6	0.238	0.062	64	46	2.6	348	91
20	0.619	0.585	0.225	64.9	0.189	0.033	65	50	2.2	345	95
21	0.568	0.532	0.151	66.8	0.171	0.035	67	51	1.3	0	94
22	0.364	0.364	-0.130	65.5	0.256	0.000	65	54	1.0	0	100
23	0.317	0.317	0.256	67.4	0.116	0.000	68	61	3.1	309	100
24	0.373	0.373	0.209	69.5	0.127	0.000	70	61	2.1	312	100
25	0.488	0.335	-0.052	70.8	0.130	0.153	70	57	1.9	0	69
26	0.204	0.204	-0.021	70.3	0.123	0.000	70	63	2.7	151	100
27	0.162	0.162	-0.255	68.0	0.576	0.000	66	60	3.1	102	100
28	0.176	0.176	0.284	69.7	0.076	0.000	69	63	1.9	0	100
29	0.255	0.255	-0.210	68.6	0.236	0.000	67	59	1.5	0	100
30	0.275	0.275	0.348	70.7	0.099	0.000	71	64	1.5	0	100
SUM	18.171	14.743	1.246	-	-	3.427	-	-	-	-	-
AVG	0.605	0.491	0.041	63.4	0.276	0.114	63	47	3.0	325	81
NBS	Q402	Q400	Q202	-	-	Q401	N405	N113	N114	N115	N400

\* DENOTES UNAVAILABLE DATA.  
@ DENOTES NULL DATA.  
N.A. DENOTES NOT APPLICABLE DATA.



# SOLAR HEATING AND COOLING DEMONSTRATION PROGRAM

## MONTHLY REPORT PASSIVE SYSTEM ENVIRONMENT

SITE: KALWALL CORPORATION  
REPORT PERIOD: APRIL, 1979

SOLAR/2015-79/04

DAY OF MON	BUILDING COMFORT ZONE 1	BLDG CCMF ZONE 2	BUILDING TEMP MIDNIGHT DEG F	BUILDING TEMP 6 AM DEG F	BUILDING TEMP NOON DEG F	BUILDING TEMP 6 PM DEG F	INTERIOR RELATIVE HUMIDITY PERCENT	AMB TEMP DEG F	DAYTIME AMB TEMP DEG F	INCIDENT SOLAR ENERGY MILLION BTU	AVG STOR TEMP DEG F
1	59	NOT	58	59	58	59	NOT APPLICABLE	43	44	0.061	59
2	57		57	57	57	58		37	37	0.012	57
3	58		58	56	59	60		41	44	0.335	57
4	60		59	56	67	62		41	52	1.939	60
5	59		59	57	59	61		38	39	0.214	59
6	60		58	58	60	63		36	39	1.681	60
7	61		59	57	63	66		37	42	2.381	61
8	63		56	56	67	66		33	47	3.536	63
9	59		56	58	58	58		38	43	0.222	59
10	62		57	55	62	61		45	41	1.222	62
11	65		61	56	69	67	NOT APPLICABLE	50	54	3.159	64
12	64		62	58	71	66		43	60	2.654	64
13	60		57	60	71	66		38	54	0.366	61
14	59		57	59	59	59		40	58	1.000	59
15	58		57	56	61	59		39	47	0.311	58
16	60		59	57	60	60		44	41	1.755	60
17	62		61	56	65	62		46	53	2.780	62
18	64		63	58	70	66		46	57	2.677	64
19	65		64	60	70	65		50	59	3.100	65
20	67		64	61	72	69		51	65	3.116	67
21	68		66	62	72	70	NOT APPLICABLE	61	65	1.422	65
22	70		68	62	74	71		61	74	2.739	67
23	71		68	62	74	74		61	77	2.938	70
24	70		68	65	74	73		57	72	2.589	71
25	70		69	66	74	73		63	72	1.659	70
26	67		65	*	67	66		60	*	0.281	68
27	69		68	65	71	72		63	73	2.332	70
28	68		66	66	67	68		59	63	0.760	69
29	71		70	64	75	75		64	76	2.769	71
30											
SUM										53.500	
AVG	63	N.A.	62	59	66	65	N.A.	47	55	1.783	63
NBS								N113			

\* DENOTES UNAVAILABLE DATA.  
@ DENOTES NULL DATA.  
N.A. DENOTES NOT APPLICABLE DATA.



















UNIVERSITY OF FLORIDA



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